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The growth of groundcherry (*Physalis angulata* L.) under low salt treatment

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Abstract. The development of crop cultivation technologies is required to augment crop productivity. It is critical to feed the expanding population in the world. This study aims to characterize the growth of groundcherry (*Physalis angulata* L.) under low salinity. The study was carried out in Bangkalan, a district on Madura Island. The treatments consisted of the application of 0 mM salinity concentration (A1) and the application of 20 mM salinity concentration in the vegetative stage (A2), generative stage (A3), and during cultivation (A4). The study was designed using eight replication in a randomized block design. Each replication comprised three plants. The root length, leaf number, height of the plant, stem diameter, fruit number, and fresh and dry weights, were measured to determine growth. The study result showed that low salinity affected the leaves number, fruit number, and dry weight. The application of 20 mM salinity concentration at the generative stage (A3) and during cultivation (A4) gave the highest growth of groundcherry.

Keywords: generative stage, growth, *Physalis*, yield

1. Introduction

Soil salinization is a growing global problem and one of the most pressing agricultural problems. Salt impedes plant growth and development while also reducing crop yield. In addition to naturally occurring soil salinization, irrigation practices, and climate change both contribute to increased salinization. Many groundwaters experience seawater intrusion which affects the quality of water for agricultural irrigation [1].

The enhanced cellular accumulation of sodium (Na^+) and chloride (Cl^-) ions in most plant species were induced by salinity stress. In saline soil and irrigated water, these are the predominant ions [2]. The toxic effect of sodium and chlorine ions on plants is caused by decreasing irrigation water quality, sodium accumulation in soil, and the potential toxicity of sodium and chlorine ions on plants [1]. Excess Na^+ in the cytosol inhibits protein synthesis, a wide range of enzymatic reactions, and photosynthetic processes. The removal of Na^+ from photosynthetic organs was therefore essential for maintaining adequate metabolic activity and effective carbon fixation [3].

Along with the rapid decline in agricultural output, research into the effects of NaCl has mainly focused on determining the impact of high concentrations (greater than 50 mM). Low-dose benefits, on the other hand, have received little attention. Only a few reports [2] show the effect of low salinity on the plant. Low salt doses can increase tomato and sunflower plant growth and yield [4,5].



The *Solanaceae* family includes several economically important species such as potatoes, peppers, eggplant, tomato, and cucumber, as well as medicinal (*Hyoscyamus niger* and *Atropa belladonna*) and ornamental species (*Petunia hybrid* and *Brugmansia suaveolens*). *Physalis* was classified as a small-fruit tree and became economically important in Colombia in 1985 [6]. Groundcherry, a weedy plant, produces the most fruit during the rainy season but can produce fruit at any time if properly watered. This species is native to tropical America but has become pantropical in Europe and Asia as a medicinal plant [7]. A low concentration of the saline solution was applied to characterize groundcherry growth.

2. Material and methods

2.1. Environmental condition

The study was carried out in Bangkalan Madura, which is 5 meters above sea level. The study took place between May and July 2022, with an average daily temperature of 34.7 °C and a minimum of 24.7 °C. The average humidity level was 67.18%.

2.2. Plant material and treatments

This study cultivated 21-day-old seedlings in red Mediterranean soil. The medium contains low levels of total nitrogen, phosphor, organic carbon, and potassium (Table 1). The seedlings were transplanted into polybags containing the specified cultivation media and grown in a greenhouse for 90 days. The treatment consisted of 0 mM salinity (A1) and 20 mM salinity that was applied at the vegetative stage (A2), generative stage (A3), and during cultivation (A4). A2 and A4 treatments were started two days after transplanting, while A3 was given when flowering began. The treatments were repeated every three days. The saline solution was prepared by dissolving salt taken from a local farmer in tap water. The volume of salt solution was adjusted to the volume of water lost due to evaporation. It was held by weighing the polybag containing soil and plants before and after watering.

Table 1. Chemical properties of the soil used as a growing medium

N (%)	P Olsen (ppm)	K (mg / 100g)	Organic carbon (%)
0.18	17.49	27.55	1.99

2.3. Growth response analysis

The growth variable includes the root length, leaf number, height of the plant, stem diameter, fruit number, and fresh and dry weights, which were measured to determine the growth of groundcherry. It was observed at 90 days after transplantation.

2.4. Statistical analysis

The study used a randomized block design with eight replications. Each replication comprises three plants. The results were analyzed using one-way ANOVA, accompanied by the Least Significant Difference (LSD) at $P \leq 0.05$.

3. Result and discussion

Low salinity at 20 mM affected the number of leaves but did not affect the height, stem diameter, and plant length. Figure 1 shows that the highest number of leaves, 602, was obtained from applying low salt at the generative stage. It did not differ significantly from the findings acquired by using low salt during cultivation with the number of leaves, with 591.71. The highest average plant height was obtained from applying low salt during cultivation at 141.33 cm. The highest average stem diameter was obtained from applying low salt at the generative stage with 14.6 mm. In contrast, the highest primary root length was obtained from applying low salt at the vegetative stage, with 67.29 mm.

At low levels, NaCl is beneficial for some plants. Na^+ replaces some of the roles of K^+ metabolism in plant cells, such as maintaining osmotic balance and being an enzymatic activator. It took place because hydrated Na^+ and K^+ have similar structures and chemical characteristics [2,8]. The impact of Na^+ on plant growth stimulation was more pronounced, especially in soils with low K^+ concentrations. The moderate potassium level in the growing media used was thought to have caused a low effect of NaCl on growth variables because some of the K needs had been met. In addition, K^+ substitution does not apply to all enzymes, especially enzymes with high K^+ selectivity as cofactors. The difference in the size of the K^+ and Na^+ ions differentiates the binding energy and coordination of enzymes [8]. At a specific dose, Cl^- may act as a micronutrient and is essential for photosynthesis, growth regulation, turgor, and osmoregulation. [9].

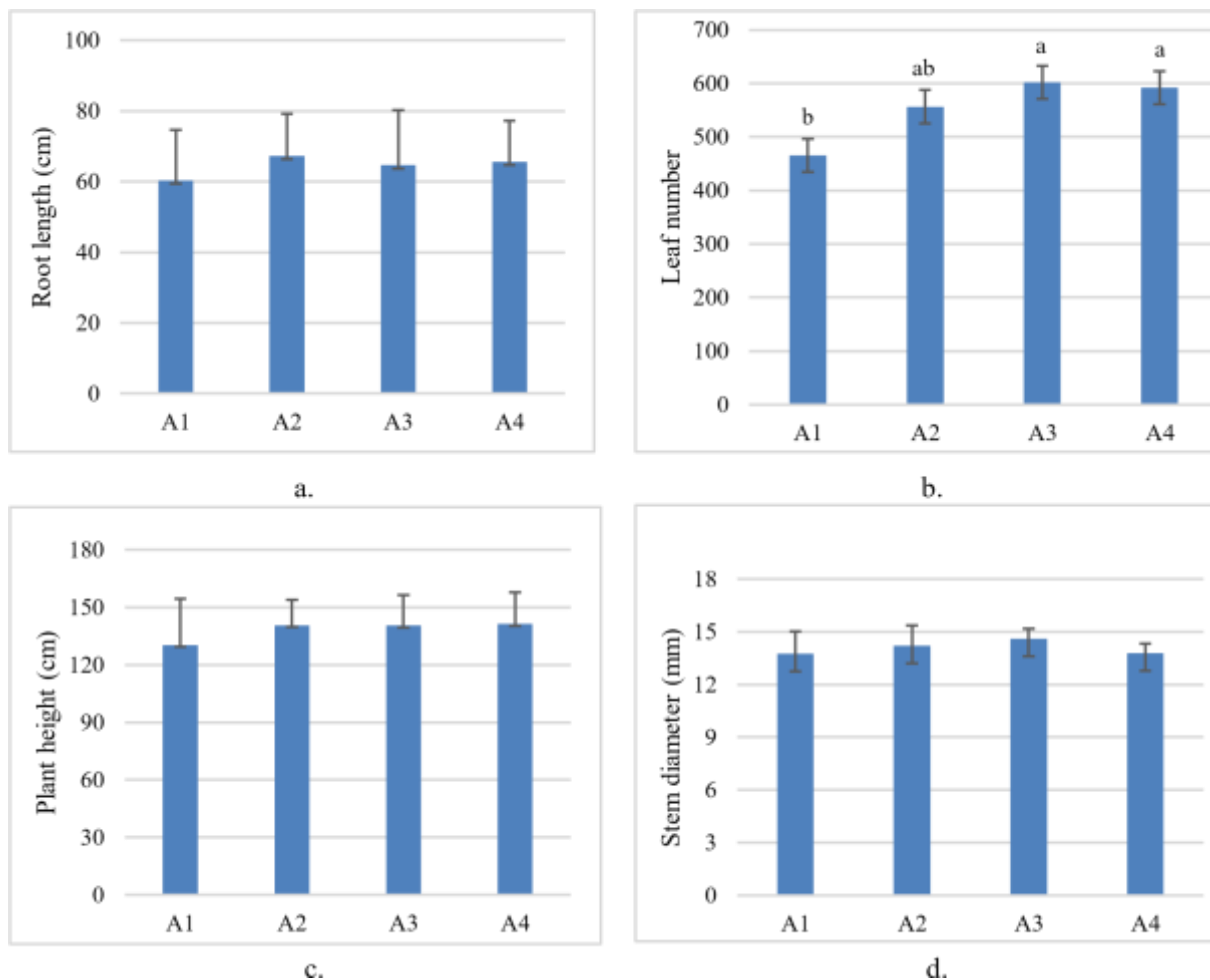


Figure 1. The growth of groundcherry on low salinity. a. Plant height b. Stem diameter c. Root length d. The number of leaves. A1 = the administration of 0 mM salt solution, A2 = the administration of 20 mM salt solution in the vegetative stage, A3 = The administration of 20 mM salt solution in the generative stage, and A4 = The administration of 20 mM salt solution during cultivation.

The number of leaves increased under low doses of salt application was also followed by increased stomatal density, but there was no effect on the chlorophyll content (Figure 2). However, applying a low dose of salt in the generative stage gave the highest stomatal density and the highest average chlorophyll. K^+ can be the principal cation responsible for ion-induced stomata function in many plant species. However, in some plants, such as *Commelina communis*, Na^+ can replace the K^+ role and is even more effective than K^+ in the stomata function [10].

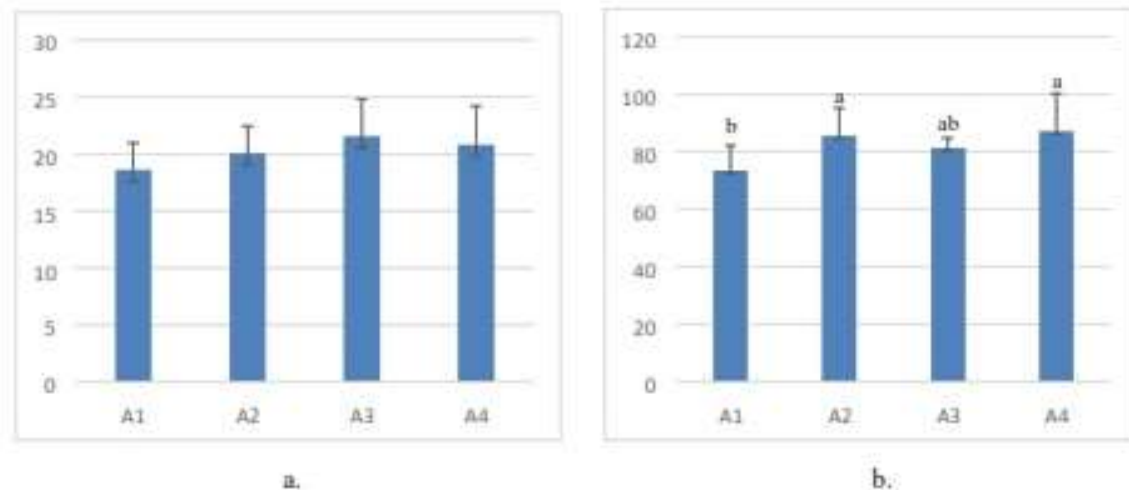


Figure 2. Physiological changes of groundcherry on low salinity. a. Chlorophyll content b. Stomata density. A1 = the administration of 0 mM salt solution, A2 = the administration of 20 mM salt solution in the vegetative stage, A3 = The administration of 20 mM salt solution in the generative stage, and A4 = The administration of 20 mM salt solution during cultivation.

Groundcherry production at low salinity, as shown in Table 2. The application of saline solution in the generative stage gave the highest number of fruits, with 143.33. It was not significantly different from the application of the salt solution during the cultivation.

Table 2. The number of fruit, fresh weight, and dry weight of groundcherry on low salinity

Treatments	Number of fruit	Fresh weight (g)	Dry weight (g)
A1	95.90 ± 23.50 c	425.87 ± 127.55	44.19 ± 12.82 b
A2	112.21 ± 30.24 bc	448.18 ± 124.63	46.23 ± 15.99 b
A3	143.33 ± 19.68 a	528.50 ± 100.86	63.20 ± 13.95 a
A4	131.25 ± 16.42 ab	473.28 ± 110.22	49.61 ± 10.40 ab

Means in columns followed by the different letters are significantly different according to the LSD test ($p \leq 0.05$). A1 = the application of 0 mM salt solution, A2 = the administration of 20 mM salt solution in the vegetative stage, A3 = The administration of 20 mM salt solution in the generative stage, and A4 = The administration of 20 mM salt solution during cultivation. 127.55, 124.63, 100.86, 110.22

Another symptom of Na deficiency is the failure of flower formation in addition to visually visible symptoms such as chlorosis and leaf necrosis. The adequacy of Na in plant tissue will stimulate the formation of flowers and fruit [10]. Chloride plays an essential role in the process of pollination and fertilization. In another in vitro study, chloride played a vital role in the elongation of the pollen tube and the polarization potential in the pollen tube during pollen germination [11,12]. The success of pollination and fertilization can increase the number of flowers that develop into a fruit. NaCl translocations in reproductive structures, fruit, and seeds are less than in leaves [13,9]. However, the synergism effect of Na^+ and Cl^- can stimulate plant growth and assimilation [14], resulting in increased carbon allocation in fruit and affecting groundcherry fruit weight.

Groundcherry fresh weight was not significantly different between low salinity treatments. The highest average wet weight was obtained from applying low salt in the generative stage of 528.50 g. In line with the growth variable, increasing fresh weight requires adding other elements. It is supported by the research of Franco-Navarro *et al.* [15] showed that the increase in fresh weight of tobacco on Cl- application was below the yield obtained from Nitrogen fertilizer. These findings highlight the importance of nitrogen as a macronutrient in promoting growth and producing more fresh weight.

The dry weight of groundcherry increased at low salinity from applying low salt at the generative stage with 63.20 g. The positive effect of treatment on growth with an increase in leaf number and stomatal density was closely related to an increase in dry weight. Similar results also occurred in tomatoes, mandarin oranges, lettuce, spinach, cereals, barley, and *Atriplex* sp [8,14].

4. Conclusion

Low salinity at a concentration of 20 mM increased the number of leaves, stomatal density, number of fruit, and dry weight. Application of saline solution for optimal growth and yield is given in the generative stage and during cultivation.

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